SUB-DRAINAGE AS APPLIED TO THE ANTI-MALARIAL CAMPAIGN ON THE ISTHMUS OF PANAMA

BY

HENRY SIMMS

SANITARY ENGINEER, GOLD COAST, FORMERLY CANAL ZONE, PANAMA

(Received for publication 30 *October,* 1908*)*

With the growing interest at present taken in anti-malarial work, and in view of the large works being at present carried out as a result of a fuller realisation of its commercial value, it is believed that the value of any information on the results of the practical application of successful methods not in general use is sufficient warrant for this article. It must be remembered that the methods described are the outcome of experience with the somewhat unusual tropical climate and topography prevailing on the Isthmus of Panama. The rainfall is very heavy, averaging about 180 inches on the Atlantic coast and 80 on the Pacific. The rainy season lasts from May to December, inclusive.

Ordinary methods in the design of sub-drainage for agricultural purposes are not applicable. For the agriculturist the object aimed at is the removal of subsoil water. For Anopheline extermination the object is to remove all water from the surface, and all puddles formed by seepage water, however small. All wet places should become thoroughly dry at least once every ten days. Here this must be accomplished in the face of continuous rains. An engineer without a knowledge of the habits of the Anophelines in question (in this case *Cellia albimanus*, *C. argyritarsis*, and *C. tarsimaculata*) would not be well equipped for the work. The results obtained by the sub-drainage work are shown by its effect on the fever rate. This rate shows the number of cases sent to the hospitals monthly as a percentage of the number of employees appearing on the rolls of the Commission.

At the start of work on the Canal, in the spring of 1904, all the energies of the Sanitary Department were directed towards the suppression of yellow fever and to the cleaning of the two ports of

Panama and Colon, the keys to the health of the Isthmus apart from malaria. Yellow fever was stamped out towards the end of 1905, and the attention of the Department was directed to the reduction of malaria. The conditions prevailing were very favourable to the propagation of this disease. What drainage had been done had been directed towards getting rid of the larger bodies of water. Vegetation was rank, and grew close up to the dwelling-quarters. Alongside the camps, consisting of unscreened houses, were native settlements, 78 per cent. of the population of which showed malaria as a result of blood examinations in fresh specimens, mostly taken from adult men. The place was swarming with Anophelines. White men direct from the North, as well as negroes, were placed in the camps. The negroes spent their evenings in the native villages. In December, 1905, of the total employees 9·63 per cent. were in the hospitals with malaria.

Systematic measures were immediately started. The general scheme was to cut all vegetation growing on soft or soggy places; to confine all water in small surface ditches, and to make a copious use of crude oil. To this was soon added the screening of buildings and cutting of all vegetation for a distance of six or seven hundred feet from the houses, which distance seemed to comprise the length of flight of the Anophelines. Quinine also played an important part. At first the labouring employees would not take the drug, but they had no objection to the more palatable mixture of quinine and rum subsequently tried. This mixture, giving 4 grains of quinine to the wineglass, was made with an inviting colour, and was very successful.

The maintenance of the open ditch system, involving re-grading, filling holes scoured out in heavy rains, removal of vegetation and algae, application of larvicides, the fact of the collapsing of banks and continual inspection, were so expensive, besides being unsatisfactory, that the authorities found it necessary to use some more permanent methods involving less annual expense in upkeep. They recognised that while there was water within reach of mosquitoes there would be larvae, as experience had shown that with the greatest care in the use of larvicides, and with the best inspection, larvae would escape destruction. They reasoned that the only practical method, in view of maintenance costs, was to get rid of the water. Sub-drainage was considered, and a first shipment of tile was ordered and installed.

The success of this was so complete that extended sub-drainage was decided on.

Tile drainage work was started early in 1906, but it was not until towards the end of the year that sufficient was laid to begin to show its effects. During 1907 the work was vigorously conducted. The figures given below will show the effect produced. It must be stated that the figures given for 1906 do not fairly express the conditions. In some districts hospitals had not yet been erected; also the coloured employees had not yet realised the value of the hospitals, and would lie about the villages and camps. It was not until a systematic inspection was started whereby the District Physician and Sanitary Inspector would visit the houses and camps, sending all cases to the hospitals, that true statistics became available. The month of March is selected as being towards the end of the dry season, and August as the period during which the fever rate reaches the highest point. The figures show the percentage of employees passing through the hospital during the month. The third column shows the annual average per 1,000 of deaths from malaria, based on the number of deaths in August for the years shown:—

	March.	August.	Annual Average per 1000 of Deaths.
1906	6·32	9·01	10·55
1907	4·16	5·33	5·05
1908	1·23	3·43	2·44

As a rule, the breeding areas giving the greatest trouble here, besides small streams, swamps, and low-lying, soggy land, are seeps on the sides and at the bases of hills from water following small areas of impervious strata. At Ancon this is specially marked. They are difficult to find, and the smallest depression holding water can breed enough Anophelines to send up the rate for a given camp.

The tile used was of three sizes: 4″, 6″, and 10″, porous and unglazed. Where the tiles had to receive seepage water only, they could be laid at grades as low as one-half per cent., care being taken to place a wisp of grass over the joints. If the soil was very bad the pipe could be surrounded, and covered for about four inches, with coarse gravel or crushed rock, and the trench filled with earth other than clay. It is necessary to make systematic borings with a 6″ augur to determine the direction of flow in the soil. Here this often follows an almost vertical direction, causing the trenches to be very close or very deep. As a rule, however, the main tile follows the course of a small stream, with feeders coming in from the side seeps. Here the problem is to lay a pipe, as a general rule through stiff clay, so that a considerable torrent can pass over it, and such that a few hours after it will remove every drop of water and suffer no damage from erosion. Such a pipe has of necessity to pass silt in quantities during freshets. Experience has shown that a 6″ pipe will satisfactorily pass silt at a grade of one per cent. and a 10″ pipe at a grade of one-half per cent. These grades can be made 'flatter' if a head can be obtained to act on the pipe, but should be avoided if it is possible. Should 'flatter' grades be required, concrete ditches or stone ditches set in cement mortar should be used.

In starting operations on a valley, the first thing to study is the best method of straightening the stream with a view to getting greater fall and a shorter distance. If the grade exceeds 5 per cent., small waterfalls should be introduced to break the velocity over the surface, during floods. The pipes should be laid at least 2′ 6″ below the bed of the stream, the trenches should be carefully graded with an instrument and the pipes laid evenly and true, with joints open to the extent of $\frac{1}{8}$″ to $\frac{1}{4}$″. They should be firmly imbedded in crushed rock on all sides, extending at least 4″ above the tile. Rock, broken to about 4″ cubes, should then be filled in, up to near the surface, and the last layer finished off in heavy stone if the scour is great. Some small stone must be placed at the top to prevent a too free entry of silt in the first rains. All side branches should be treated in the same way, and should connect to the main with Y junctions. When surface water has to run in volume over the pipe, the outfall should be carefully planned so as to pass the water away quickly, and should be strong enough to stand the scour that occurs at this point.

It would appear probable that after a short time the porous stone placed over the pipe would completely clog, but this does not occur. What happens is that the first heavy rains completely cover the stone with about 2″ of coarse granular earth. The grass quickly grows over this and forms a complete mat over which the rain runs without erosion. The air from below keeps this mat very porous, and the mat then acts as a filter for future rain. Care must be taken to cut down any trees the roots of which will interfere with the pipes.

In the case of seeps, if the borings made do not give sufficient data, two or more holes must be dug and the slope that the water is following determined. This is sometimes so steep that parallel pipes have been laid, 10′ apart and 5′ deep, to catch completely the water, as it is essential that all water should be intercepted.

With regard to cost, it must be remembered that the cost of transportation and labour is exceedingly high on the Isthmus. A good labourer receives $1.80 per day U.S. currency. Some work would be in inaccessible valleys, and complete roads would have to be built. Rock would often have to be transported by train and then carried over hills. This transportation has made the work considerably more costly than it would be in other places. The average cost of the tile put in so far is about 35 cents per foot, about 1s. 3d. of which is the first cost of the tile. The cost of maintenance of open ditches for the year amounted to 25 cents per foot, so that in less than a year and a half the work has paid for itself, apart from the great reduction in malaria and the great saving in the cost of the care of the sick. The work is yet far from complete, and much remains to be done.

From the experience gained here it would appear that sub-drainage work is the only practical means, taking into consideration the cost of upkeep, for permanent anti-malarial work. In a climate such as this, and where Anophelines breed in clear running water during all months of the year, the annual expense of the open ditch system is prohibitive.